An investigation of elementary preservice teachers’ self-efficacy for teaching mathematics

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Abstract: Research has consistently shown that teacher efficacy is related to a variety of desirable student outcomes, thus, making teacher efficacy an important factor in high quality mathematics instruction. The purpose of this study was to determine elementary preservice teachers’ self-efficacy beliefs related to teaching mathematics. Forty-one participants from a single university responded to the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) after completing a constructivist-based elementary mathematics methods course prior to student teaching. The MTEBI is a 21-item survey using a 5-point, forced choice Likert-like scale to provide an individual’s perceptions of mathematics teaching efficacy beliefs on two subscales—Personal Mathematics Teaching Efficacy Belief (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE). Responses on the PMTE subscale (Mean = 51.08, SD = 5.171) indicate that the respondents’ personal mathematics teach efficacy is positive. Participants’ responses (Mean = 29.32, SD = 3.29) on the MTOE subscale indicate positive expectations of students’ mathematics learning. Attending to preservice teacher efficacy is worthy of examination. Teacher

ABOUT THE AUTHORS

Rebecca McMahon Giles, PhD, is an elementary and early childhood professor at the University of South Alabama in Mobile, where she coordinates the K-6 Teacher Education program. She has over 25 years of experience teaching preschool through adults. Her research interests include young children's literacy development and teacher preparation.

Kelly O. Byrd, MEd, is a senior instructor at the University of South Alabama. She teaches mathematics methods courses to preservice teachers as well as serves as a field experience supervisor. She is a doctoral candidate in Mathematics Education at The University of Southern Mississippi, Hattiesburg, MS.

Angelia Bendolph is a doctoral candidate in Instructional Design and Development at the University of South Alabama. She currently serves as president of the IDDGA student group. In addition, Angelia served as a graduate assistant in the Center of Evaluation, Measurement and Statistics for the summer and fall 2015 semesters.

PUBLIC INTEREST STATEMENT

Teachers’ confidence in their own teaching abilities is known as self-efficacy. Teachers with high self-efficacy beliefs possess more beneficial characteristics than those with lower self-efficacy beliefs, making high self-efficacy a desirable trait for teachers. Mathematics teaching self-efficacy refers specifically to a teacher’s belief in his/her ability to teach mathematics effectively. The growing number of career opportunities that require advanced mathematical understanding makes it essential that every child is prepared for high school and college mathematics as a result of having had an elementary teacher confident in his/her abilities to teach mathematics effectively. The immediate and long-term positive impacts of high mathematics teaching self-efficacy on student performance make it a topic of significant interest and particular importance to teacher educators. This study examined elementary preservice teachers’ self-efficacy beliefs regarding mathematics instruction and found that preservice teachers who participated in a constructivist-based mathematics course had positive mathematics teaching efficacy as well as positive expectations of students’ mathematics learning.
preparation programs must identify opportunities to positively impact mathematics teaching efficacy of preservice teachers.

Subjects: Education; Initial Teacher Training; Mathematics; Primary/Elementary Education

Keywords: teacher preparation; self-efficacy; mathematics; elementary education; preservice teacher

1. Introduction

Research indicating that teachers make the defining difference in the academic success of students (Center for Public Education, 2005) has contributed to increasing demands on institutions of higher education to prepare teachers who can immediately contribute to the improved achievement of all students (Council for the Accreditation of Educator Preparation, 2015). Similarly, research has consistently shown that teacher efficacy is related to a variety of desirable student outcomes, such as achievement and motivation, making teacher efficacy an important factor in high-quality mathematics instruction (Newton, Leonard, Evans, & Eastburn, 2012). Teachers who express disaffection with mathematics are more likely to avoid planning or teaching the subject (Trice & Ogden, 1986), while teachers with high teaching mathematics efficacy are more likely to engage students in inquiry and student-centered teaching, which are linked to higher achievement (Swarz, Hart, Smith, Smith, & Tolar, 2007). Implementation of effective instructional practices in mathematics has been linked to teacher efficacy (Enon, 1995), and highly efficacious teachers are more effective mathematics teachers than teachers with a lower sense of efficacy (Swarz, 2005). Further, Chang (2015) found that fifth-grade mathematics teachers’ efficacy significantly influenced both their students’ mathematics self-efficacy and mathematical achievement, which was consistent with findings of previous studies (Ashton & Webb, 1986; Rosenholtz, 1989) linking teacher’s mathematical self-efficacy to students’ attitudes and abilities.

1.1. Teacher efficacy

Efficacy beliefs have long been associated with the work of psychologist Albert Bandura (1977), who defined efficacy as intellectual activity by which one develops one’s beliefs about his or her ability to achieve a certain level of accomplishment. Bandura advocated that people develop specific beliefs concerning their coping ability to change what he called “self-efficacy” and defined as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). While individuals with high self-efficacy may accomplish tasks far beyond their capabilities, those with low self-efficacy might underestimate their abilities and, as a result, underachieve (Bandura, 1982). Thus, the perception of one’s capabilities to perform a task will increase the likelihood that the task will be completed successfully because people’s behaviors are usually guided by their perceptions of self-efficacy rather than their actual capabilities (Pajares, 2002). In reality, “beliefs are far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior” (Pajares, 1992, p. 311). The strong effect of one’s confidence to perform specific tasks on behavior has made self-efficacy of particular interest to educational researchers (Albion, 1999).

The value and power of teachers’ sense of efficacy have been well established in the literature (Knoblauch & Woolfolk Hoy, 2008; Putman, 2012). Teachers who have confidence in their own teaching abilities (i.e. a greater sense of self-efficacy) provide a greater academic focus in the classroom (Gibson & Dembo, 1984), try new methods and persist with students who struggle (Honey, Lumph, Czenoki, & Egan, 2002; Nurlu, 2015), engage in a greater degree of ongoing staff development programs (Gersten, Chard, & Baker, 2000), and place more importance on building a warm relationship with their students (Nurlu, 2015) than their peers with lower perceptions of their ability to influence student learning. Additionally, a strong sense of efficacy “can pay dividends of higher motivation, greater effort, persistence and resilience” (Tschanenn-Moran, Hoy, & Hoy, 1998; p. 238). Further, teacher self-efficacy has a direct link to students’ performance (Chang, 2012; Dembo & Gibson, 1985;
Pajares, Usher, & Johnson, 2007; Woolfolk & Hoy, 1990) and is considered a powerful influence on teachers’ overall effectiveness with students (Pendergast, Garvis, & Keogh, 2011).

Graham, Harris, Fink, and MacArthur (2001) assert that teachers’ efficacy is “one of the few teacher characteristics that reliably predicts teacher practice and student outcomes” (p. 178). Because self-efficacy is based on self-perceptions regarding particular behaviors, the construct is considered to be situation specific or domain sensitive resulting in the development of multiple instruments to measure the self-efficacy of pre- and inservice teachers in various domains. Mathematics teaching efficacy refers to one’s beliefs in their ability to teach mathematics effectively (Enochs, Smith, & Huinker, 2000).

1.2. Preparing preservice teachers to teach mathematics

As suggested by Avery and Meyer (2012), promoting preservice teacher self-efficacy requires an environment that is at once challenging and appropriately nurturing. McLaughlin (2015) advocates for methods courses that provide opportunities for preservice teachers to enjoy doing science and assist in the development of the knowledge, skills, and habits of mind necessary to become competent and confident professionals. Similarly, courses in math methods should contribute to improved self-efficacy for math after particular instructional methods and learning activities.

The Curriculum and Evaluation Standards for School Mathematics (National Council of Teachers of Mathematics, 1989) outlined five goals for all students to: (1) learn to value mathematics, (2) become confident in their ability to do mathematics, (3) become mathematical problem solvers, (4) learn to communicate mathematically, and (5) learn to reason mathematically. Although these goals were written for K-12 students, it is especially important that the teachers of mathematics at every level achieve these goals as well. Participants in the current study were enrolled in an elementary mathematics methods where these goals were constantly revisited as preservice teachers were reaching new levels of understanding of the K-6 content through hands-on, inquiry-based activities. Experiences and activities were designed in hopes that the preservice teachers, upon completion of this course, would be more confident in their ability to do and teach the mathematics in grades K-6.

The elementary mathematics methods course included instruction on lesson planning and effective teaching strategies, such as questioning, use of manipulatives, and writing in the elementary classroom. Emphasis was placed on understanding and implementing the Common Core State Standards of Mathematics content standards as well as the Standards for Mathematical Practice (Common Core State Standards Initiative, 2010). A constructivist approach was taken in examining mathematical topics along with the most effective ways of guiding the learning of these topics.

Integrating mathematics across the curriculum was also a focus resulting in the implementation of STEM (Science, Technology, Engineering, and Mathematics) and art-integrated lessons. When discussing particular mathematical concepts, the preservice teachers were encouraged to think about how their students would understand concepts, not memorize a particular skill. For many of the preservice teachers, this course provided their first introduction to any form of manipulatives, commercial, or teacher-made. The focus was always discovery-based learning rather than memorization so that the preservice teacher would develop a deeper, more conceptual understanding of the mathematics they would be required to teach.

To transfer what they were learning in the course to their field placement, preservice teachers were required to write and teach a minimum of three mathematics constructivist lessons. They were required to use inquiry-based teaching, incorporating manipulatives, interactive whiteboard activities, children’s literature and/or art. Higher order thinking questions were required in the lesson plans to foster elementary students’ communication and understanding. After teaching each lesson, the preservice teachers provided written reflections about their experiences teaching mathematics to elementary students.
As a final project in the elementary mathematics methods course, the preservice teachers reflected on their overall experiences learning and teaching mathematics in through coursework as well as in their field experience classroom. Specifically, preservice teachers reflected upon the mathematics lessons they planned, prepared, and taught; their confidence level in teaching mathematics; and how they think about doing and teaching mathematics.

The purpose of this study was to obtain and measure elementary preservice teachers' self-efficacy beliefs regarding mathematics instruction. Taking into consideration, the immediate and long-term impact of positive teacher-efficacy related to teaching mathematics, findings from this investigation will be of interest to current educators and administrators, certification and licensing boards, and those responsible for the training and monitoring of new teachers. The observations that teacher education programs can influence the development of preservice teachers' self-efficacy and identity (Charalambous, Philippou, & Kyriakides, 2008; Palmer, 2006; Pendergast et al., 2011) makes the topic of preservice teachers' self-efficacy for teaching mathematics of particular importance to teacher educators.

2. Methodology
A posttest only research design was used for this study. A pretest was not administered to avoid testing threat, where taking a test affects subsequent testing by increasing participants' performance as a result of their familiarity with the test items. The participants were selected as a convenience sample of preservice teachers enrolled in the elementary mathematics methods course previously described.

2.1. Participants
This study took place at a large research university situated in an urban city in the south-eastern United States. The university is classified by the Southern Association of Colleges and Schools as a Level VI institution and by the Carnegie Foundation for the Advancement of Teaching as Doctoral/Research Intensive University. The College of Education where the participants were enrolled consists of approximately 1,600 students, and the participants' program (K-6 Teacher Education) is the largest in the college.

Participants were 41 elementary preservice teachers enrolled in a constructivist-based mathematics methods course. They were concurrently enrolled in a science methods course and a field experience course which required them to accumulate a minimum of 150 field hours divided between both regular and special education elementary classroom settings. All participants were seeking a Class B teaching certificate in both Elementary Education and Collaborative Teaching (K-6), and participant demographics were typical of this program; they were all female, seniors, and predominantly Caucasian (32 Caucasian and 9 African-American).

2.2. Instrument
Enochs et al. (2000) modified the Science Teaching Efficacy Belief Instrument (Enochs & Riggs, 1990) to create the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), which measures mathematics teaching efficacy beliefs in preservice teachers. The MTEBI was used as the data collection instrument in this study. The 21-item MTEBI uses a five-point, forced-choice response Likert-type scale ranging from “Strongly Agree” to “Strongly Disagree” to obtain individual’s perceptions of mathematics teaching efficacy beliefs on each of the two subscales—Personal Mathematics Teaching Efficacy (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE). A response of “Strongly Agree” indicates the highest level (5) of perceived efficacy, whereas “Strongly Disagree” indicates the lowest level (1). Eight items (3, 6, 8, 15, 17, 18, 19 and 21) are reverse scored. The PMTE scale consists of 13 items (2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, and 21). The MTOE scale consists of 8 items (1, 4, 7, 9, 10, 12, 13, and 14). Thus, PMTE scale scores range from 13 to 65 while MTOE scores range from 8 to 45.
2.3. Data collection and analysis
Quantitative, descriptive statistics were used to determine the level of participants’ mathematics teaching efficacy. The survey was disseminated to a convenience sample of 41 elementary preservice teachers during the last week of their second semester of methods courses in the K-6 Teacher Education program immediately prior to their Student Teaching semester.

Due to missing data from one participant, only 40 responses were analyzed for the study. Participation in this survey research was voluntary, and there were no identified risks or benefits to participants.

3. Results
Responses for the PMTE subscale (see Table 1) reflect student responses to the questionnaire items as a mean score. Table 1 also lists the rank of the student responses based on the mean score. There were six questions with a mean score greater than 4 (Q2, Q20, Q15, Q8, Q19, and Q11, respectively) indicating that the respondents answers range from agree to strongly agree of their perceptions of mathematics teaching efficacy (see Figure 1).

Responses for the MTOE subscale (see Table 2) reflect student responses to the questionnaire items as a mean score. Table 2 also lists the rank of the student responses based on the mean score. Question 9 had a mean score greater than 4 indicating that the respondents’ answers range from agree to strongly agree of their perceptions of MTOE (see Figure 2).

The Cronbach alpha for the MTOE and PMTE subscales was .679 and .765, respectively. The PMTE subscale met the .7 or higher recommended measurement, while the MTOE was near the recommended measurement level. The Cronbach alpha measures the internal consistency of items, indicating the degree that the items are interrelated (Johnson & Christensen, 2014, p. 170).

Table 1. PMTE subscale results

<table>
<thead>
<tr>
<th>Item stem</th>
<th>Mean</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2 I will continually find better ways to teach mathematics</td>
<td>4.58</td>
<td>.747</td>
<td>1</td>
</tr>
<tr>
<td>Q3 Even if I try very hard, I will not teach mathematics as well as I will most subjects</td>
<td>3.35</td>
<td>1.051</td>
<td>12</td>
</tr>
<tr>
<td>Q5 I know how to teach mathematics concepts effectively</td>
<td>3.6</td>
<td>.591</td>
<td>11</td>
</tr>
<tr>
<td>Q6 I will not be very effective in monitoring mathematics activities</td>
<td>3.85</td>
<td>.921</td>
<td>8.5</td>
</tr>
<tr>
<td>Q8 I will generally teach mathematics ineffectively</td>
<td>4.23</td>
<td>.832</td>
<td>4</td>
</tr>
<tr>
<td>Q11 I understand mathematics concepts well enough to be effective in teaching elementary mathematics</td>
<td>4.03</td>
<td>.577</td>
<td>6</td>
</tr>
<tr>
<td>Q15 I will find it difficult to use manipulatives to explain to students why mathematics works</td>
<td>4.28</td>
<td>.554</td>
<td>3</td>
</tr>
<tr>
<td>Q16 I will typically be able to answer students’ questions</td>
<td>3.88</td>
<td>.463</td>
<td>7</td>
</tr>
<tr>
<td>Q17 I wonder if I have the necessary skills to teach mathematics</td>
<td>3.2</td>
<td>1.018</td>
<td>13</td>
</tr>
<tr>
<td>Q18 Given a choice, I will not invite the principal to evaluate my mathematics teaching</td>
<td>3.68</td>
<td>.971</td>
<td>10</td>
</tr>
<tr>
<td>Q19 When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better</td>
<td>4.13</td>
<td>.563</td>
<td>5</td>
</tr>
<tr>
<td>Q20 When teaching mathematics, I will usually welcome student questions</td>
<td>4.45</td>
<td>.597</td>
<td>2</td>
</tr>
<tr>
<td>Q21 I do not know what to do to turn students on to mathematics</td>
<td>3.85</td>
<td>.893</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Table 2. MTOE subscale responses

<table>
<thead>
<tr>
<th>Item stem</th>
<th>Mean</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort</td>
<td>3.63</td>
<td>.774</td>
<td>5</td>
</tr>
<tr>
<td>Q4 When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach</td>
<td>3.68</td>
<td>.859</td>
<td>3.5</td>
</tr>
<tr>
<td>Q7 If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching</td>
<td>3.28</td>
<td>.877</td>
<td>7</td>
</tr>
<tr>
<td>Q9 The inadequacy of a student’s mathematics background can be overcome by good teaching</td>
<td>4.05</td>
<td>.552</td>
<td>1</td>
</tr>
<tr>
<td>Q10 When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher</td>
<td>3.65</td>
<td>.662</td>
<td>4</td>
</tr>
<tr>
<td>Q12 The teacher is generally responsible for the achievement of students in mathematics</td>
<td>3.7</td>
<td>.608</td>
<td>2</td>
</tr>
<tr>
<td>Q13 Students’ achievement in mathematics is directly related to their teacher’s effectiveness in mathematics teaching</td>
<td>3.68</td>
<td>.73</td>
<td>3.5</td>
</tr>
<tr>
<td>Q14 If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child’s teacher</td>
<td>3.53</td>
<td>.751</td>
<td>6</td>
</tr>
</tbody>
</table>
4. Discussion

Preservice teachers in this study had positive levels of efficacy regarding their mathematics teaching abilities as well as positive levels of outcome expectancy for their students in mathematics. These findings are consistent with Briley (2012) who also found the elementary preservice teachers in his study to have moderately strong beliefs in their capabilities to teach mathematics effectively, even with their limited mathematics teaching experiences. Interestingly, results showed higher levels of perceived personal efficacy for teaching mathematics than those of Bursal and Paznokas (2006), who found that half of the 65 preservice teachers enrolled in a mathematics methods course felt that they would not be able to teach mathematics effectively.

Research supports the idea that teacher efficacy can be developed among preservice teachers (Charalambous et al., 2008; Palmer, 2006). It has been suggested that methods courses may be particularly critical for the development of teacher efficacy, possibly as a result of the opportunity for structured and well-support field experiences in conjunction with such courses (Utley, Moseley, & Bryant, 2005). Likewise, studies have indicated that elementary preservice teachers’ participation in a mathematics methods course corresponds to significant increases in mathematics teacher efficacy (Cakiroglu, 2000; Huinker & Madison, 1997; Wenta, 2000). The positive self-efficacy for teaching mathematics reported by the elementary preservice teachers in this study could be at least partially attributed to their engagement in the constructivist learning activities during their math methods course along with multiple opportunities to teach mathematics to elementary students and reflect upon these two types of experiences afterward.

Since teacher efficacy plays an important role in promoting students’ learning achievement and their self-efficacy development in the classroom, teacher educators must provide better teacher preparation programs for pre-service teachers’ efficacy development (Chang, 2015; Incikabi, 2013). As suggested by Briley (2012), mathematics courses for elementary preservice teachers that are taught in a more constructivist manner that encourages reflections on their mathematical beliefs might bring about more lasting change to their mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy, which might continue on into their teaching careers.

Programs of study in higher education must effectively prepare preservice teachers to teach mathematics in order for their students to be provided opportunities for success. It is important for teacher education programs to ensure that field experiences enhance and apply what preservice teachers learned in the university classroom by giving detailed feedback about strengths and
weaknesses, so they can reflect and learn from both their successes and mistakes (Rohrkemper & Corno, 1988). As Chang (2015) states “Mathematics teacher educators must devote extensive efforts to establish a positive and collaborative working and in-service learning environment that promotes mathematics teacher efficacy” (p. 1308).

5. Limitations
As in all studies, there are some limitations that should be acknowledged. In this study, participants were a convenience sample of elementary preservice teacher from one university enrolled in a single semester; therefore, the generalizability of the findings is limited. The small sample size of participants also limits the findings to a larger population. Further, the demographics of the participants in this study may limit generalizability to participants with of different ages, ethnicities, certification areas, and/or educational levels. Finally, the data collection instrument was a survey, and, though the participants remained anonymous, the self-reporting nature of survey research is a limitation in itself.

6. Future research
Additional research using additional data collection measures, such as direct observations and interviews, to triangulate the data and increasing the number of participants would strengthen findings. Since the passage of time has also been shown to have a negative effect on self-efficacy following designed experiences (Moseley, Reinke, & Bookout, 2002), measuring preservice teachers’ teaching mathematics efficacy at various points throughout their preparation program would be useful for determining the influence, if any, of factors such as methods courses and early field experiences on perceptions of their ability to organize and execute teaching that promotes learning in mathematics.

Putman (2012) found that experienced teachers held the highest general teaching efficacy when compared to novice and student teachers. While not surprising that veteran teachers have higher efficacy than beginning teachers, it would be interesting to follow preservice teachers into student teaching and beyond in order to examine whether and how their mathematics teaching efficacy changes as they gain pedagogical knowledge and teaching experience.

Research (Newton et al., 2012; Swars, 2005) suggests that elementary preservice teachers’ mathematics teaching efficacy may be linked to prior mathematics learning experiences. Further research examining the possible relationship between factors such as prior experiences and/or mathematics content knowledge and efficacy of elementary preservice teachers would be helpful as preparation programs are designed and refined. Finally, research that connects preservice teachers’ mathematical self-efficacy to the academic achievement of their students would be highly beneficial, since teachers’ self-efficacy belief toward their mathematics teaching is directly associated with the increase of students’ achievement in mathematics (Nurlu, 2015).

7. Conclusion
The growing number of career opportunities that require advanced mathematical understanding makes it essential that every child is prepared for high school and college mathematics, thus, necessitating that every elementary teacher is confident in his or her abilities to teach mathematics effectively. Attending to preservice teachers’ self-efficacy for teaching mathematics is paramount. Teacher preparation programs must examine their general education mathematics requirements along with their mathematics methods courses and field experiences to identify opportunities to positively impact mathematics teaching efficacy of preservice teachers.
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Author details
Rebecca McMahon Giles1
E-mail: r.giles@southalabama.edu
Kelly O. Byrd1
E-mail: kbyrd@southalabama.edu
ORCID ID: http://orcid.org/0000-0001-9915-1391
Angelia Bendolph1
E-mail: ab1104x@gmail.southalabama.edu
1 Department of Leadership and Teacher Education, College of Education, University of South Alabama, UCON 3100, 75 University Blvd.N., Mobile, AL 36688-0002, USA.

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References


